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SOLAR HEAT TRANSFER SYSTEM (HTPL), <u>H</u>igh <u>T</u>emperature <u>P</u>ressurized <u>L</u>oop

BACKGROUND OF INVENTION

This invention pertains to collection and delivery of heat from a roof or ground mounted solar collector panel to a hot water storage tank via the use of a pressurized fluid loop. The pressurized loop system utilizes a water antifreeze mixture or other suitable fluid is circulated via a pump. In addition the system is protected from over-temperature and over-pressure if the circulating pump fails. The high temperature fluid heat transfer loop allows for a smaller heat transfer area and hence more compact, hot water tank heat exchanger and a small diameter, approximately 2 Inch diameter, flexible insulated umbilical containing both electrical and fluid tubing connections, approximately ¼ Inch outside diameter tubing, to go to and from the hot water tank to the solar collector for ease of installation. The saving in materials for heat exchangers, piping, insulation, and the self protection from overheating, make this collector system unique.

PRIOR ART

Most common solar collector systems are un-pressurized and use a heat exchanger external to the water tank to exchange heat from the un-pressurized solar loop to the city water pressure in the hot water tank. Un-pressurized collector heat transfer loops are limited to the boiling point water antifreeze mixtures, typically 50/50, at atmospheric pressure of approximately 220 degrees Fahrenheit. A water antifreeze mixture of approximately 50/50, pressurized to fourteen PSI, or approximately two atmospheres in the collector loop will not boil until 265 degrees Fahrenheit. The higher operating temperature in the collector loop allows for efficient in tank heat exchangers to be utilized, which do not disturb the normal tank stratification. Internal tank heat exchanger also eliminates the pump would circulate water from the hot water tank through the external heat exchanger. The stratification of the normal hot water tank, hot on top and cooler on the bottom, is disturbed by circulating water from the hot water storage tank, through the external heat exchanger. It is important not to disturb the normal tank stratification, because it decreases the normal gas or electric heater efficiency.

Some solar collectors use City line water pressure and flow this city water through the collector to heat it. These systems are called integrated collector storage, roof mounted systems. The city potable water is subject to freezing and must be heated electrically at night to keep the collector from freezing during cold weather. Other systems, which circulate potable through the collectors when they're illuminated by the sun, must drain this water out at night during freezing weather.

Main advantages: 1) Pressurized heat transfer loop Allows solar collectors to operate up to 265 degrees Fahrenheit; 2) Pressurized heat transfer loop allows heat to be transferred with very low fluid flow rates minimizing pumping power and allowing small diameter tubes to take fluid to and from the solar collector and water tank heat exchanger; 3) Internal heat exchanger adapts to existing tanks with minimum re-plumbing and without tank removal or draining; 2) Heat exchanger is efficient; 3) Double wall heat exchanger safely separates toxic heat transfer fluids from potable water; 4) This solar system costs less to install and maintain; and 5) Solar system maintains normal tank stratification.

SUMMARY OF INVENTION

In summary, the present invention is a Pressurized fluid loop, where heat is collected in a solar panel illuminated by the sun, heats a solution of water based antifreeze or other suitable liquid, the fluid is pumped at low flow rate to a hot water tank where it gives up the heat via an internal heat exchanger. The fluid loop is pressurized and operates above the normal boiling point of water 212 Fahrenheit. The fluid loop also has built in over-temperature and over-pressure protection built in, so if the fluid circulation pump stops, that the system will not get too hot and damage itself.

The primary objective of the present invention is to reduce the amount of material needed to collect and transport solar heat. This is accomplished buy increasing the temperature in the fluid loop, which decreases the area of the hot water tank to fluid loop heat exchanger surface. The higher fluid temperature difference, between the hot water tank and the solar collector allow more heat to be stored in each unit volume of fluid in the solar collector heat transfer loop. Hence a smaller volume of fluid, lower flow rate, is needed to deliver the heat from the solar collector to the hot water tank. The higher fluid temperature in the collector will lower the collectors efficiency, since it is loosing heat to the outside air. This loss is a small price to pay for a system using significantly less material.

Another objective is to reduce the time and complexity of retrofitting solar energy to existing homes, since it uses flexible small diameter tubing to carry the low fluid flow volume. The small diameter of the fluid carrying tubes, approximately ¼ Inc outside diameter, also allows them to be thermally insulated and still be less than 2 inches in diameter. By adding an electrical wire bundle to the insulated fluid carrying tubes and wrapping them with a protective covering an umbilical cord is created, which carries all fluids and electrical signals from the hot water tank to the solar collector. This plug and play umbilical allows for do-it-yourselfers or professionals to install the system more quickly. These fluid carrying tubes can be installed in existing buildings, because they

are flexible and can be fed into and through attics, walls and placed on the outside of buildings, without being unsightly.

Additional objectives, advantages and novel features of the invention will be set forth in part in the description which follows and in part will become apparent to those skilled in the art upon examination of the following. Others may be learned by practice of the invention. The objectives and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the pressurized loop solar collector system, including the fluid loop, the solar collector, the hot water tank heat exchanger, the fluid pump and controller and the over-pressure and pressure activated over-temperature systems.

FIG. 2 is a view of the over-pressure system and its associated fluid recovery system, with the external fluid recovery system.

FIG. 3 is a pressure activated solar collector over-temperature control system, which opens dampers in the collector to let heat out, when the fluid in the loop boils and raises the loop pressure.

FIG. 4 is a boiling activated solar collector over-temperature control system, which forces fluid from the main fluid loop into a liquid to air heat exchanger ,radiator, to let heat out of the fluid loop, when the fluid in the loop boils

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention consists of a pressurized heat transfer loop, which operates well above the boiling point of water at one atmosphere, 212 degrees Fahrenheit (FIG. 1). The water is heated, by the sun, in the single, or double glazed, solar collector (1), an integral part of the collector is a set of damper, which are opened by pressure (15). These dampers are only open when the solar heat collected is more than the hot water tank can use. These dampers when opened allow outside air of less than 120 degrees Fahrenheit to flow over the absorber plate, where the sunlight is converted to heat and transferred into the heat transfer fluid. This airflow cools the absorber and stops the boiling. Then the dampers close and the absorber heats back up. The dampers open and close on a 2 to 5 minute cycle and only minor boiling is allowed to take place. This self-controlling feature is unique and allows the collector to protect it self, even if the fluid flow in the pressurized loop (17) stops. Alternatively to the dampers, or along with them one could use the system shown in (Fig 4, (29)), which is a pressurized side channel to the main pressurized heat transfer loop, which is at the uppermost point in the main fluid loop. As gas bubbles form in the solar collector they try to escape by going into the side channel heat exchanger. The fluid there is below the boiling point of the pressurized fluid and

they collapse and condense. The fluid is the side channel is cooler, because the outer surface is exposed to the outside air. If no bubbles are forming in the solar collector, then there is no flow of fluid in the side channel and the fluid the side channel stays cool.

The system has two possible configurations for activating the heat transfer fluid pump (12). The first is a conventional control system run from household 115VAC power. This control system has a control box (11), which plugs into the wall outlet and has three sensors. The collector has a temperature sensor using low voltage (8) who's electrical wires are part of the umbilical, to tell the controller, which turns on the pump, when the collector temperature exceeds the hot water tank temperature, measured by sensor (10) at the bottom of the hot water tank. There is also a sensor in the top of the tank (9), which tells the controller the tank is getting to hot, ie no one home to use hot water, then the controller will shut off the pump. This would now cause the pressure damper or side channel heat exchanger to protect the collector from excessive boiling, which will block the collector tubes with scale in time.

The second pumping system is based on using a photovoltaic array (6), which provides 12 Volt power when the sun is shining. This power is carried down to the pump on the umbilical connector wire. The pump is a DC powered pump, which is capable of low flow at modest pressures. There is no control box. When the sun is out the pump pumps, when it is not, the pump stops. A thermal disconnect switch (18), is place on the top of the hot water tank, so if it gets too hot, it will disconnect the pump.

The internal tank heat exchanger adapter (13), screws into the inlet or outlet port of the hot water tank (14) the house water to be heated now exits or enters the tank now via a side arm of the adapter. The pressurized loop heat exchanger fluid enters and exits the adapter in small diameter copper tubing, like quarter inch outside diameter copper tubing.

To transport the pressurized fluid and the heat it contains from the solar collector to the hot water heater and flexible insulated umbilical is used (7). The umbilical consists of the thermally insulate fluid connections and the low voltage electrical connections in one easy to run length. The two small diameter copper tubes, hot collector fluid to the hot water tank and cooler fluid retuning from the hot water tank to the collector, are held apart by a spacer, such as a polymer coating applied to each, so the can be placed next to each other without touching and tied together along their length. This allows the two-tube bundle to be flexible and insulated with a ¾ inch thick insulating jacket and still be less than 2 inches in diameter. Adding a wire cable to the outside of the umbilical allows sensor (8) to be easily connected to the controller. The small diameter copper tubes are connected together with standard ¼,5/16, or 3/8 unions and T-connectors (5).

The invention also consists of a pressure relief and fluid overflow recovery system (Fig 2). and includes a pressurized fluid reservoir (3), a pressure cap to regulate the pressure in the system, and allow the overflow to return on system cool down at night (2), which is connected to a fluid overflow and recovery reservoir (4). The pressure of the fluid in the solar collector heat transfer loop is regulated by the pressure cap, which uses a spring to push against the fluid pressure over a fixed area. During normal daily operation when the sun is out, the heat transfer fluid expands as it heats from 75 degrees Fahrenheit to over 230 degrees Fahrenheit and when the pressure reaches the set pressure, i.e. 16 PSI, fluid overflows to the fluid overflow reservoir (21), which is vented to the atmosphere by a cap

(30). At night, when the fluid in the solar heat transfer system cools and contracts, fluid is drawn back into the heat transfer system to keep if full of fluid and keep air out. Air in the system increases the corrosion of the fluid loop. This simple system allows the approximately 50% water / 50% antifreeze mixture in the solar heat transfer loop to heat up to over 212 degrees Fahrenheit, without boiling until it reaches almost 265 degrees Fahrenheit, at 16 PSI confinement pressure. This high temperature allows for heat to be transferred more efficiently into the hot water tank, using lower flow rates and an internal (or external) hot water tank heat exchanger.

The invention also consists of a pressure activated solar collector over-temperature protection system (Fig 3). This system consists of a solar system fluid pressure-activated actuator (16), such as a piston (22), or other pressure-activated actuator, which is in a retracted state at atmospheric pressure and an extended state at the pressure cap relief setting, such as 16 PSI. A spring (20) or pressurized cavity can be used to return the actuator to the retracted state, when the solar system pressure falls to atmospheric. The solar system fluid (21) is sealed into the system via a bellows (23) or other acceptable seal, such as an O-ring. The actuator is connected to the fluid loop (17).

This actuator output (24) is connected to a hinged or sliding valve (25,26), like a furnace damper, which allows air to flow over the solar collector absorber plate and cool it off with outside air. Over-temperature protection is achieved by successive airflow events over the solar collector absorber plate. When the solar collector gets too hot the heat transfer fluid (21) boils in the collector. This causes the pressure actuator to extend and open to collector air damper valves, which take the heat out of the solar collector and the heat transfer fluid drops below the boiling point and stops boiling. The system pressure returns to atmospheric and the actuator retracts and closes the collector air damper valves. This cycle repeats itself until the sun goes down, or the fluid flow is reestablished. Thus the collector prevents damage to the system, by keeping the collector near the boiling point of the water/antifreeze mixture, if the hot water tank is hot enough, the pump fails to circulate the heat transfer fluid, or the fluid flow path is blocked. The inset in Figure 3 shows that the actuator and air valve position as a function of system pressure. The air valves are shut and the actuator retracted until a pressure of approximately 80% of the system pressure, maintained by the pressure cap is reached. Their air valves are open and the actuator extended by the time the system reaches 95% of the system pressure maintained by "the radiator cap". This arrangement allows the system to cool itself before vigorous boiling occurs. The pressure vs. actuator position profile is determined by the piston area (22) and spring (20) constant.

The invention also consists of a boiling activated solar collector over-temperature protection system (Fig 4). The system consists of a liquid to air heat exchanger and a boiling gas separator. During normal operation they entire system is full of heat transfer fluid (21) and no boiling occurs. The liquid to air heat exchanger (29) is a side arm and normally has no fluid flow in it. Normally the fluid flows into the boiling gas separator from the solar collector and out of it down to the hot water tank. Under abnormal conditions such as circulating pump failure or the solar input being greater than the hot water tank can use, the solar collector will begin to boil. In this event the boiling gas